NEEGINAN INSTITUTE

WINNIPEG, MANITOBA

WELDING PROCEDURE SPECIFICATION

FOR SMAW

OF CARBON STEEL

Welding Procedure Specification No.: SMA-CS

Date: February 2010

CWB APPROVAL	ENGINEER'S SEAL
	SAMPLE

1.0 SCOPE

This Welding Procedure Specification covers welding and related operations of steel structures in accordance with terms outlined in CSA Standards W47.1 and W59, latest editions.

A change in any of the essential variables specified in CSA W47.1-09, which are contained in succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet (WPDS) will require a new Welding Procedure Specification and/or a new WPDS.

2.0 WELDING PROCEDURE

The welding shall be done manually using a Shielded Metal Arc Welding process (SMAW).

The joints shall be made in accordance with procedural stipulations indicated in CSA Standard W59 and may consist of single or multiple passes.

Welding shall be in accordance with the CWB approved Welding Procedure Data Sheets contained in Appendix D.

Each WPDS designates the electrode type to be used for the joint, applicable Codes or Standards, material specifications, the number of the applicable Welding Procedure Specification and detailed information for use in the actual welding of the joint.

3.0 BASE METAL

The base metal shall conform to the specifications for carbon steels as listed in Groups 1, 2 & 3, Tables 11-1 & 12-1, CSA W59-03.

Other groups may be welded provided the Welding Procedure Data Sheets have been accepted by the Canadian Welding Bureau.

4.0 BASE METAL THICKNESS

Base metal thickness from 1/8 inch (3mm) to UNLIMITED THICKNESS may be welded under this specification.

Base metals 3/16 inch and under may be welded under the requirements of AWS D1.3, providing the respective Welding Procedure Data Sheets have been accepted by the Canadian Welding Bureau.

5.0 FILLER METAL

Filler metal shall conform to specifications for Mild Steel Covered Arc Welding Electrodes in CSA Standard W48 Latest edition and shall be certified in one of the classifications of that Standard by the Canadian Welding Bureau.

Low-hydrogen electrodes shall be used for the welding of all steels except that they need not be used for steels listed in Column 2 of Table 5.3 in CSA W59-03 (see Appendix B). However, if notch toughness is a consideration for steels in Column 2, then electrodes having appropriate impact properties shall be selected.

Any increase in electrode diameter greater than 1/32" (1 mm) requires a separate WPDS.

Electrodes shall be properly cared for and stored as further detailed in Appendix A "CARE OF ELECTRODES".

6.0 POSITION

The welding shall preferably be performed in the flat position, however, it may be done in all positions (i.e. flat, horizontal, vertical or overhead) provided the applicable Welding Procedure Data Sheet has been accepted by the Canadian Welding Bureau.

Unless called for otherwise on a specific CWB approved WPDS, vertical welds shall be made with the progression of each pass in an upward direction, with the exception that:

a) When using CWB certified electrodes specifically designed for vertical down progression of welding.

b) For root passes that are to be completely removed by back gouging.

c) When repairing undercuts, provided that the greater of the minimum permissible preheat temperature or 50^0F (10 C) is maintained.

d) If welds are to be made in the vertical down sequence, the welder and procedure shall be qualified on a separate basis.

7.0 PREPARATION OF BASE METAL

Edge preparation of the base metal will generally be done by plasma or arc machine gouging, grinding or by shearing.

Where hand cutting is involved, the edge will be ground to a smooth surface.

All surfaces and edges shall be free from ribs, cracks, or any other defects which would adversely affect the quality of the weld.

Re-entrant corners, except for the corners of weld access cope holes adjacent to a flange, shall be contoured to a radius not less than ½" (12mm).

Transitions shall be ground to provide a suitable joint for a sound weld.

Radii of beam access copes and weld access holes shall provide a smooth transition, free of notches or cutting past the points of tangency between the adjacent surfaces. Surface roughness shall be in accordance with the requirements of CSA W59-03 Clause 5.3.3.

Weld access hole dimensions shall conform to the requirements of CSA W59-03 Clause 5.3.8.

All loose or thick scale, rust, moisture, grease, paint, or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed within 2" (50 mm) of any surface to be welded.

Plate edges & weld preparations shall be visually examined prior to fabrication to detect the possible presence of planar edge discontinuities, in accordance with Clause 5.3.5 of CSA W59-03.

Assembly and fit-up tolerances for all weld joint types shall conform to CSA W59 Clause 5.4 or AWS D1.3, as applicable.

8.0 PREHEAT

Preheating of carbon steel is not normally required in temperate conditions.

Welding shall not be performed when the ambient temperature is lower than 0^0F (-18 C) without express consent of the Engineer. When the base metal temperature is below 32^0F (0 C) OR the minimum temperature outlined in Table 1, Appendix B for the welding process, electrode classification, material specification or thickness being used, it shall be preheated.

8.0 PREHEAT (Cont'd)

The minimum preheat temperature to be obtained before welding shall be in accordance with Table 5.3 of CSA W59-03, which is reproduced in Appendix B. Welding shall be done at a rate which ensures that the minimum preheat is maintained or exceeded.

The minimum preheat temperature shall be applied for a minimum distance equal to the material thickness, but not less than 3", both laterally and in advance of the welding.

If welding is interrupted for some time so that the temperature of the base metals falls below the minimum preheat temperature, then preheat shall again be applied prior to recommencing welding.

The weldment shall be allowed to cool naturally to the ambient temperature without any external quench media being supplied. Any cold air, drafts, or moisture, shall be avoided during the cooling time until the weldment cools down to below 600 °F (315 C) maximum.

9.0 ELECTRICAL CHARACTERISTICS

Welding current may be AC or DC, reverse or straight polarity with amperage and voltage settings as noted in the individual welding procedure data sheets attached. Welding machines shall have a variable voltage characteristic and deliver at least 32 arc volts.

10.0 WELDING TECHNIQUE

The welder, the work, and the welding consumables shall be adequately protected against the direct effect of wind, rain, and snow, and all reasonable means shall be provided to enable the welder to work in reasonable comfort.

Refer to the WPDS for the precise SMAW variables to be used in a particular thickness and joint configuration, position and parameters, such as amperage, voltage, travel speed, passes & layers, etc.

Welding currents must be within the specified limitations of the respective manufacturer and in addition should not vary more than ±10 amps maximum from the currents noted on the individual Data Sheets. The maximum width of weave for manual shielded metal-arc electrodes shall be 2-times the nominal electrode diameter.

Arc strikes outside the area of welds should be avoided on any material.

10.0 WELDING TECHNIQUE (Cont'd)

For electrodes of the low-hydrogen classification, a short, close contact area shall be maintained using a steady progression technique with minimal use of whipping. The maximum weld deposit which can be made with a single pass shall be as shown in Table 1:

TABLE 1

Type of Joint	Pass Number	Welding Position			
		Flat	Horizontal	Overhead	Vertical
Fillet	Root Pass	3/8"(10mm)	5/16"(8mm)	5/16"(8mm)	1/2"(12mm)
	Filling Layers	1/8"(3mm)	3/16"(4mm)	3/16"(4mm)	1/16"(2mm)
Groove	Root Pass	1/4" (6mm)			
	Filling Layers	1/8"(3mm)	3/16"(4mm)	3/16"(4mm)	1/16"(2mm)

11.0 WELD METAL CLEANING

Any slag or flux, remaining in the weld area after any weld pass, shall be removed before applying the next covering pass.

All finished welds shall have the slag removed.

12.0 TREATMENT OF UNDERSIDE OF WELDING GROOVE

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged, ground or chipped to sound metal, unless otherwise specified on the applicable data sheet. Alternatively, the joint will include a continuous metal backing strip that will be included in the welded joint.

Back-gouging shall produce a groove contour substantially conforming to a pre-qualified single U-joint, with a depth adequate to ensure complete penetration into the previously deposited weld metal.

13.0 QUALITY

In general, the weld quality shall be such as to meet the requirements of Clauses 5.9, 11.5.4 and/or 12.5.4 of CSA Standard W59-03.

Welds shall meet the desirable or acceptable weld profiles shown in Appendix C.

Cracks or blow holes that appear on the surface of any pass shall be removed before depositing the next covering pass.

The procedure and technique shall be such that undercutting of base metal or adjacent passes shall be kept to a minimum. Undercut shall be limited to 1/32 inch (0.8mm) deep.

All welds shall be free from overlap.

Fillet welds in any single continuous weld shall be permitted to underrun the nominal fillet weld size required by 1/16" without correction, provided that the undersize weld does not exceed 10% of the length of the weld and does not occur at the ends of the web-to-flange welds in girders for a length equal to twice the width of the flange.

The reinforcement in groove welds shall not exceed 1/8 inch (3mm) and shall have a gradual transition to the plane of the base metal surface.

Surfaces of butt joints required to be flush shall be finished so as not to reduce the thickness of the thinner base metal or weld metal by more than 1/32" nor 5% of the thickness, whichever is smaller, or leave reinforcement that exceeds 1/32". All reinforcement must be removed where the weld forms part of a faying or contact surface.

14.0 HEAT TREATMENT AND STRESS RELIEVING

Post-weld heat treatment and stress relieving will not normally apply to structures welded under this specification unless specifically shown on the approved welding procedure data sheets. When required, procedures for heat treatment will be prepared and submitted for approval prior to start of work.

15.0 DATA SHEETS

The WPDS attached in Appendix D form part of this specification.

A change in any of the essential variables specified by CSA W47.1-09, which are shown in the attached WPDS will require a new data sheet.

Appendix A CARE OF ELECTRODES

Once electrodes have been removed from their original package, they must be stored in a suitable enclosure to preserve their specified properties and welding characteristics.

Low-hydrogen electrodes that conform to CSA Standard W48-01 shall be delivered in sealed containers, which show no evidence of damage.

Low-hydrogen electrodes that do not conform to the above shall be reconditioned in accordance with applicable item a), b) or c). Electrodes that are wet shall be discarded.

a) Carbon steel electrodes conforming to CSA W48-01 shall be baked for at least two hours at a temperature between 450^0F (230 C) & 500^0F (260 C).
b) Low-alloy steel electrodes conforming to CSA W48-01 shall be baked for at least one hour at a temperature between 700^0F (370 C) & 800^0F (430 C).
c) Alternative baking temperatures for low-hydrogen electrodes may only be used if such procedures have been developed and are recommended by the Manufacturer and have received the prior approval of the Engineer.

Immediately after being removed from undamaged sealed containers or after being reconditioned, low-hydrogen electrodes shall be stored in an oven held at a temperature of at least 250 °F (120 C).

Low-hydrogen electrodes of the E49 (E70) classification that are not used within 4 hours after removal from ovens shall be reconditioned as noted above or discarded. Low-hydrogen electrodes with higher strength than the E49 classification that are not used within 2 hours shall be reconditioned per item c) above.

Low-hydrogen electrodes shall only be reconditioned once.

Auxiliary electrode containers or dispensers may be used for E49 (E70) classification electrodes to extend exposure times under the following conditions:

a) The engineer shall be satisfied that the storage container or dispenser have been demonstrated to provide adequate atmospheric sealing protection for the electrodes at a relative humidity of 90% at 86^0F (30 C) for the total storage time required.
b) The electrodes will not produce diffusible hydrogen levels in the weld metal in excess of the requirements of CSA W48-01
c) Electrodes not used within 10 hours of being placed in a storage container or dispenser shall be reconditioned as noted above or discarded.

Electrodes other than the low-hydrogen type must be stored in warm and dry conditions and must be kept from dirt, oil, grease, moisture and all other deleterious matter.

Appendix B PREHEAT

Preheat of the base material in the immediate area of the joint is essential in medium and high carbon steels as well as in heavy sections. Preheat must also be employed when the ambient temperature dictates.

Preheat is used to:

Reduce shrinkage stresses especially in highly restrained joints;

Provide a slower cooling rate through the critical temperature (1600°F to 1330°F) or (870C to 720C), thus preventing excessive hardening and lower ductility in the heat affected zone;

Provide a slower cooling rate through the 400°F (205C) range to allow for hydrogen diffusion.

Preheat and interpass temperatures for various steels covered by this specification must be applied with a minimum as shown in Table 5.3 of CSA W59-03.

Welding shall not be done when the ambient temperature is lower than 0 °F (-18C), except with express consent of the Engineer.

When the base metal temperature is below the temperature listed for the welding process being used and for the thickness of the material being welded, it shall be preheated (except as otherwise provided) in such a manner that the surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded - but not less than 3 inches - both laterally and in advance of the welding.

Preheat and interpass temperatures must be sufficient to prevent crack formation. For quenched and tempered steel, the maximum preheat and interpass temperature shall not exceed 400°F (200C) for thickness up to 1 1/2 inches inclusive, and 450°F (225C) for greater thickness. Heat input, when welding quenched and tempered steel, shall not exceed the steel producer's recommendations.

Preheat and interpass temperature may be reduced when approved by the Engineer and/or the Bureau for techniques established by the Contractor that will guarantee satisfactory properties for the joint in its full length.

Table I Minimum preheat and interpass temperature (Ref. Table 5-3 of W59-03)

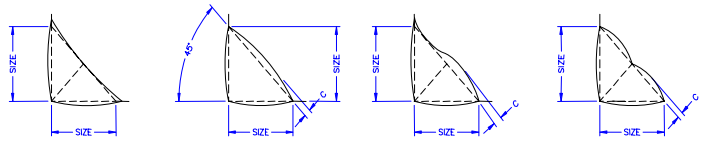
Thickness of Thickest part at point of welding (inches)	Welding Process			
	SMAW with other than low-hydrogen designators	SMAW low-hydrogen electrodes		
1	2	3	4	5
	CSA G40.21 38W, 38WT 44W, 44WT	**CSA G40.21** 38W, 38WT 44W, 44WT 50W, 50WT 50A, 50AT 60A, 60AT 60W, 60WT	**CSA G40.21** 60 W, 60WT 70 W, 70WT 70A, 70AT	**CSA G40.21** 100Q 100QT
	ASTM A36 A53 Gr. B A106 Gr. B A500 Gr. B A501 A501 Gr. 55, 60 A529 A570 All grades A572 Gr. 42, 50 A607 Gr. 45, 50*	**ASTM** A36 A53 Gr. B A106 Gr. B A242# A441 A500 Gr. A,B,C A501 A515 up to Gr. 60 A501 All grades A529 A570 All grades A572 Gr. 42, 50 A588 A606 A607 All grades A618 A633 Gr. A,C,D A710 Gr. A Cl 2 <2″ A913 Gr. 50 A992/A992M	**ASTM** A515 Gr. 60,65 A572 Gr. 60, 65 A633 Gr. E A710 Gr. A Cl 2 <2″ A710 Gr. A Cl 3 >2″ A913 Gr. 60, 65	**ASTM** A514 A517
Up to 3/4 inclusive Over 3/4 to 1 1/2 Over 1 1/2 to 2 1/2 Over 2 1/2	None! 150 °F (65 C) 225 °F (107 C) 300 °F (150 C)	None! 50 °F (10 C) 150 °F (65 C) 225 °F (107 C)	50 °F (10 C) 150 °F (65 C) 225 °F (107 C) 300 °F (150 C)	50 °F (10 C) 125 °F (50 C) 175 °F (80 C) 225 °F (107 C)

Grades suitable for welding.

! When the base metal temperature is below 32 °F (0 C), the base metal shall be preheated to at least 50 °F and this temperature maintained during welding.

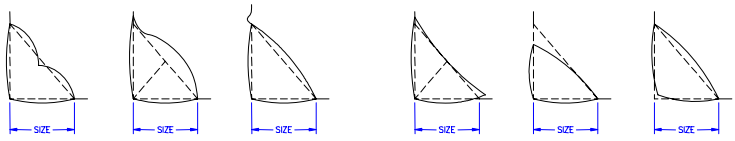
* Only for thicknesses up to 5/16" (8 mm).

APPENDIX C ACCEPTABLE AND DEFECTIVE PROFILES OF WELDS

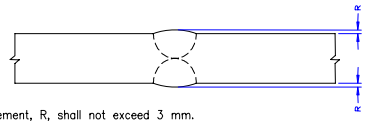


NOTE: Convexity, C, of a weld or individual surface bead shall not exceed 0.07 times the actual face width of the weld or individual bead, respectively, plus 1.5 mm.

(a) Desirable Fillet Weld Profiles (b) Acceptable Fillet Weld Profiles

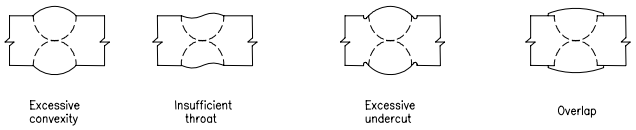


(c) Unacceptable Fillet Weld Profiles



NOTE: Reinforcement, R, shall not exceed 3 mm.

(d) acceptable Groove Weld Profiles in Butt Joints



(e) Unacceptable Groove Weld Profiles in Butt Joints

Notes:

(1) The faces of fillet welds may be slightly convex, flat, or slightly concave. Except at outside corner joints, the convexity shall not exceed 0.07 X width of face or bead + 15. mm.

(2) The finishing passes of all groove welds in butt joints shall provide a reinforcement at the centre of weld not exceeding 3mm. The reinforcement shall be built up uniformly from the surface of the parent metal to a maximum at the centre of the weld. There shall be no valley or groove along the edge or tin the centre of the weld. The deposited metal shall be smooth and uniform in cross-section.

Appendix D Welding Procedure Data Sheets